EVALUATION OF MULTIPLE-STAGE LINT AND MILL CLEANING FOR CONTROLLING COTTON-DUST LEVELS IN CARDROOMS

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Evaluation of Multiple-Stage Lint and Mill Cleaning for Controlling Cotton-Dust Levels in Cardrooms

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ABSTRACT

Spindle-picked cotton was ginned with multiple lint-cleaning sequences and two mill-cleaning setups to determine the effects of gin- and mill-cleaning levels on the quantity of airborne dust in a model cardroom, the rate of microdust buildup in open-end spinning-frame rotors, and other manufacturing and yarn-quality factors. The experiment showed that using supernormal quantities of lint cleaning at the gin in combination with maximum mill cleaning reduced cardroom dust levels but did not provide enough reduction in airborne dust levels to suggest that gin lint cleaning can offer a real expectation of reaching the low level of 0.2 milligram per cubic meter of cardroom dust proposed by the Occupational Safety and Health Administration. The loss of one staple length (one thirty-second of an inch) resulting from treatment with four saw-cylinder lint cleaners, along with the accompanying lowered yarn strength, are warnings that the use value of cotton fibers as competitive textile raw materials may likely be destroyed by multiple-stage lint cleaning before the proposed allowable dust level in the cardroom is attained. KEYWORDS: cotton, cotton dust, cotton ginning, lint cleaning, open-end spinning.

INTRODUCTION

It is common knowledge that cotton dust is considered to be a health hazard in the cotton industry, especially in textile mills (Morgan 1975), and that it may also cause production problems in open-end spinning systems through particle buildup in rotors (Barella et al. 1975). Two kinds of ginning procedures are being explored for the control of cotton dust in mills: (1) the application of liquid additives to cotton at gins (Cocke et al. 1978) and (2) more intense cleaning of cotton in overhead and lint-cleaning machinery (Towery and Baker 1979). Neither of these procedures alone is entirely satisfactory. The experiment reported here was designed to determine the effects of several lint-cleaner sequences at the gin and two subsequent levels of mill cleaning on cardroom dust levels, dust buildup in rotors, and the performance of cotton so cleaned in an open-end spinning system. We also attempted to determine the effects of the lint-cleaner sequences on raw-cotton quality and farmer income.

METHODS AND MATERIALS

The cotton used in the experiment was 'Stoneville 213' grown and harvested by the Delta Branch of the Mississippi Agricultural and Forestry Experiment Station at Stoneville, Miss. Twenty-three

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thousand pounds of seed cotton were harvested by a spindle picker and stored in a 20-bale bin for 2 weeks. The cotton was removed from the bin by suction and preprocessed through a standard seed-cotton cleaning arrangement for machine-picked cotton. The cotton was then deposited on trailers for conditioning and ginning in a small-scale gin in which the atmosphere was maintained at 75° F and 55 percent relative humidity. Three one-bale batches were ginned with each of the following lint-cleaning treatments:

1. No lint cleaning (NOLC), control treatment.
2. Two stages of saw-cylinder lint cleaning (2SCLC).
3. One air-jet lint cleaner followed by two saw-cylinder lint cleaners in series (1AJLC+2SCLC).
4. Three air-jet lint cleaners and two saw-cylinder lint cleaners in alternating sequence (3AJLC+2SCLC).
5. Four saw-cylinder lint cleaners in series (4SCLC).

The saw-cylinder lint cleaners had 12-inch-diameter saws that were operated at a saw speed of 1,140 revolutions per minute and with a combing ratio of 29 : 1. The air-jet lint cleaners were adjusted for minimum lint loss.

The three bales from each lint-cleaning treatment were opened behind adjacent blending feeders. Half of the cotton was routed through a vertical opener, lattice opener, pepper shaker, and superior cleaner for maximum (MAX) mill cleaning. The other half was fed directly to the picker and was designated as minimum (MIN) mill cleaning. A 14-ounce-per-yard lap was formed at picking. The picker laps for each mill-cleaning treatment were divided to form three processing lots of approximately 240 pounds each, which resulted in a total of 30 processing lots. The picker laps were carded at 20 pounds per hour to produce a 50-grain-per-yard sliver. At breaker drawing, a 53-grain-per-yard sliver was formed at a front-roll speed of 265 feet per minute. At finisher drawing, a 55-grain-per-yard sliver was formed at a front-roll speed of 265 feet per minute. The finisher-drawing sliver was spun on a Platt type 883 Rotospin open-end spinning frame. A 50.7-tex (11.6-Ne)[3] yarn was formed with a 5.0 twist multiplier at a rotor speed of 46,000 revolutions per minute. Each lot was spun for 20 hours.

[3]Ne, symbol of the indirect system of arriving at the yarn number. It denotes length per unit mass or the number of hanks (840 yards) required to weigh 1 lb; thus, the larger the Ne number, the smaller the yarn size.

RESULTS AND DISCUSSION

Cardroom dust levels ranged from 3.44 milligrams per cubic meter of air for the NOLC-MIN treatment combination to 2.18 milligrams per cubic meter for the 4SCLC-MAX combination (table 1). The air-jet lint cleaners had no significant effect on cardroom dust levels and may be dropped from consideration so far as these measurements are concerned in this study. The average cardroom dust level for the lint-cleaner treatments involving two saw-cylinder lint cleaners (2SCLC, 1AJLC+2SCLC, and 3AJLC+2SCLC) for both mill-cleaning levels was 2.62 milligrams per cubic meter, and average measurements of 3.19, 2.67, and 2.35 milligrams per cubic meter were obtained

Table 1. — Amounts of airborne dust in the cardroom and quantities of rotor residue after multiple lint-cleaning treatments and two levels of mill cleaning[1]

Treatment combination[2]	Airborne dust[3] (mg/m³)	Rotor residue[4] (mg/kg/rotor)
Minimum mill cleaning:		
NOLC	3.44a	0.077
2SCLC	2.86b	.071
1AJLC+2SCLC	2.63cd	.084
3AJLC+2SCLC	2.80bc	.079
4SCLC	2.52d	.071
Maximum mill cleaning:		
NOLC	2.94a	.073
2SCLC	2.48b	.075
1AJLC+2SCLC	2.45b	.080
3AJLC+2SCLC	2.53b	.077
4SCLC	2.18c	.079
Average, minimum and maximum mill cleaning:		
NOLC	3.19a	.075ab
2SCLC	2.67b	.073b
1AJLC+2SCLC	2.54c	.082a
3AJLC+2SCLC	2.66b	.078ab
4SCLC	2.35d	.075ab
Average, all lint cleaning:		
Minimum mill cleaning	2.85y	.077y
Maximum mill cleaning	2.52z	.076y

[1]Means in the same treatment category for the same measurement followed by unlike letters are significantly different at the 95-pct confidence level.

[2]Minimum mill cleaning=Picker only. Maximum mill cleaning=Vertical opener, lattice opener, pepper shaker, and superior cleaner. NOLC=No lint cleaner (control). SCLC=Saw-cylinder lint cleaner. AJLC=Air-jet lint cleaner.

[3]By vertical elutriator.

[4]Platt modified-standard rotor.

for the NOLC, 2SCLC, and 4SCLC treatments, respectively. This relationship appears to be asymptotic and suggests that lint cleaning at gins will not reduce the foreign matter in cotton sufficiently to meet the cardroom dust-level limit of 0.2 milligram per cubic meter proposed by the Occupational Safety and Health Administration (OSHA). The four-stage mill-cleaning treatment (MAX) reduced the average cardroom dust level from 2.85 to 2.52 milligrams per cubic meter. It should be pointed out that no air was used on the cleaning devices during carding in order to obtain elevated dust levels for testing purposes. The current industrial practice of using about 1,050 cubic feet per minute of air on the cleaning device of the card would have resulted in dust levels approximating 25 percent of those reported here.

The buildup of residue in the Platt modified-standard rotors used in this experiment did not correlate with either differences in lint-cleaner treatments or level of mill cleaning. The NOLC-MIN and 4SCLC-MAX treatment combinations gave similar rotor residue values of 0.077 and 0.079 milligram per kilogram per rotor, respectively.

Manufacturing waste, composed of opening, picking, and carding wastes, was affected by both level of mill cleaning and number of lint-cleaning stages used at the gin (table 2). The saw-cylinder lint cleaners were more effective than the air-jet lint cleaners in reducing manufacturing waste; however, the air-jet lint cleaners were set for minimum lint loss, which implies that they were less effective in removing foreign particles than they might have been at another setting.

The amount of spinning-end breakage indicated by ends-down data did not show effects consistent with the quantity of gin and mill cleaning, even though some of the values were statistically different from others. The yarn produced was of good quality and was affected little or not at all by

Table 2. — Manufacturing-waste contents and selected yarn-property values after multiple lint-cleaning treatments and two levels of mill cleaning[1]

Treatment combination[2]	Manufacturing waste (pct)	Ends down (No./1,000 spindle-hours)	Break factor	Yarn appearance index	Uster irregularity CV (pct)
Minimum mill cleaning:					
NOLC	6.38	49	1934	116	14.0
2SCLC	3.36	35	1944	123	14.4
1AJLC+2SCLC	3.11	26	1976	119	14.1
3AJLC+2SCLC	2.95	46	1961	119	14.1
4SCLC	2.45	65	1880	117	14.4
Maximum mill cleaning:					
NOLC	8.03	58	1949	119	13.9
2SCLC	3.93	68	1914	114	14.4
1AJLC+2SCLC	4.09	40	1956	117	14.3
3AJLC+2SCLC	3.89	56	1968	122	11.2
4SCLC	3.45	41	1875	113	14.4
Average, minimum and maximum mill cleaning:					
NOLC	7.21a	54a	1941b	117c	13.9b
2SCLC	3.64b	52a	1929b	119b	14.4a
1AJLC+2SCLC	3.60b	33b	1966a	118b	14.2ab
3AJLC+2SCLC	3.42c	51a	1964a	121a	12.6c
4SCLC	2.95d	53a	1878c	115d	14.3ab
Average, all lint cleaning:					
Minimum mill cleaning	3.65y	44y	1939y	119y	14.2y
Maximum mill cleaning	4.68z	52z	1933y	117z	13.6z

[1]Means in the same treatment category for the same measurement followed by unlike letters are significantly different at the 95-pct confidence level.

[2]Minimum mill cleaning=Picker only. Maximum mill cleaning=Vertical opener, lattice opener, pepper shaker, and superior cleaner. NOLC=No lint cleaner (control). SCLC=Saw-cylinder lint cleaner. AJLC=Air-jet lint cleaner.

Table 3. — Quantity of waste removed, in pounds per bale, by individual lint cleaners[1]

Treatment	Lint-cleaner sequence[2]							Total
	AJLC	SCLC	AJLC	SCLC	AJLC	SCLC	SCLC	
2SCLC		19.5a		8.6a				28.1a
1AJLC+2SCLC	2.8a	17.7b		9.0a				29.5a
3AJLC+2SCLC	2.7a	17.6b	0.5	8.3a	0.2			29.3a
4SCLC		17.6b		9.8a		7.4	5.3	40.1b

[1]All data normalized to 500 lb of lint ginned.

[2]AJLC=Air-jet lint cleaner. SCLC=Saw-cylinder lint cleaner. Means in a column followed by unlike letters are significantly different at the 95-pct confidence level.

Table 4. — Foreign-matter contents, bale weights, grade designations, staple lengths, lint values per pound, and bale values after multiple lint-cleaning treatments

Measurement	Treatment combination[1]				
	NOLC	2SCLC	1AJLC+ 2SCLC	3AJLC+ 2SCLC	4SCLC
Foreign-matter content[2] pct	6.70a	3.40b	3.25b	3.05b	2.22c
Bale weight[3] lb	500	472	471	471	460
Grade designation	SGO	SLM	SLM	SLM	SLM
Staple length 32d inch	35	35	35	35	34
Lint value per lb[4]	56.79¢	64.39¢	64.39¢	64.39¢	64.04¢
Bale value	$284	$304	$303	$303	$295

[1]NOLC=No lint cleaner (control). SCLC=Saw-cylinder lint cleaner. AJLC=Air-jet lint cleaner.

[2]Shirley Analyzer total waste. Means followed by unlike letters are significantly different at the 95-pct confidence level.

[3]Weights adjusted for lint-cleaner waste.

[4]Memphis spot price October 19, 1978.

amounts of gin or mill cleaning, except that the 4SCLC treatment produced slightly weaker yarn than did the other lint-cleaner treatments.

The effect of the lint-cleaner treatments on raw-cotton quality and farmer income was considerable. The treatments removed from 28.1 to 40.1 pounds of waste per bale (table 3). The influence of the sequential positions of the lint cleaners on quantity of waste removed clearly shows that the first units removed more material than did the following units.

The lint-cleaner treatments caused consistent reductions in the quantity of foreign matter remaining in lint. The four saw-cylinder lint cleaners removed a significant amount of foreign matter when compared with the treatments having two saw-cylinder lint cleaners or those having one or three air-jet lint cleaners plus two saw-cylinder lint cleaners (table 4), but this had little effect on cardroom dust level (table 1). The most intensive gin- and mill-cleaning treatments produced a cardroom dust level 10 times greater than the allowable limit proposed by OSHA.

The highest bale values were obtained by the 2SCLC treatments (table 4). These treatments improved the lint grades two full steps over that of the NOLC treatment, and the 4SCLC treatment did not further improve the lint grade designation.

CONCLUSIONS

The use of supernormal quantities of lint cleaning at the gin in combination with maximum mill cleaning, although decreasing the cardroom dust levels, did not provide enough reduction in the airborne dust level to suggest that gin lint cleaning can offer a real expectation of reaching the low level of cardroom dust proposed by OSHA. The loss of one staple length (one thirty-second of an inch) resulting from the 4SCLC treatment, along with the accompanying lowered yarn strength (break factor), are warnings that the use of cotton fibers as competitive textile raw materials may likely be destroyed by multiple-stage lint cleaning before

the allowable dust level in the cardroom is attained. Further, the loss in bale weight and bale value would discourage cotton producers from this kind of ginning under the present cotton marketing system.

We conclude that methods other than gin lint cleaning and mill cleaning are needed to control the level of cotton dust in textile mills.

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